CALIFORNIA COMPENDIUM OF PLAGUE CONTROL, 2006

CALIFORNIA DEPARTMENT OF HEALTH SERVICES
DIVISION OF COMMUNICABLE DISEASE CONTROL
VECTOR-BORNE DISEASE SECTION

The purpose of this compendium is to provide information on plague to California's public health and environmental health officials, medical professionals, veterinarians, vector control professionals, and other parties interested in plague surveillance and control in the state. The recommendations below are reviewed and updated on a periodic basis to reflect the current status of plague and plague prevention activities in California. Updates are based on a review of the scientific literature on plague, and consultation with the Centers for Disease Control and Prevention, the World Health Organization, the Council of State and Territorial Epidemiologists, and academia.

PART I
PLAGUE ECOLOGY IN CALIFORNIA

A. Causative Agent

The plague bacillus, *Yersinia pestis.*

B. History of Plague in California

Plague was first recorded in California and the United States in San Francisco in 1900. Plague appeared in Los Angeles in 1908. The disease most likely was introduced into these and other West Coast seaports via infected rats and humans arriving aboard ships from Asia. Outbreaks in rats and human epidemics followed the introduction of plague to both San Francisco and Los Angeles. These plague epidemics involved domestic rats, rat fleas, and humans. Through flea exchange, plague transferred to native wild rodents and was first isolated from native ground squirrels and woodrats in California in 1908. A pneumonic plague epidemic in humans occurred in 1919 in Oakland and was traced to an index patient who hunted and skinned native ground squirrels. Thirteen of 14 cases in this epidemic were fatal. A second epidemic of 32 cases, 31 of which were fatal, occurred in Los Angeles in 1924. The Los Angeles epidemic was associated with an epizootic among domestic rats and ground squirrels in east Los Angeles. The 1924 epidemic is the last known instance of human-to-human plague transmission in the United States. There was a total of 426 human plague cases in the early California epidemics between 1900 and 1925. Fifty-five percent (234) of these cases were fatal.

Since the early epidemics, 59 additional human plague cases have been reported in California, all directly or indirectly associated with sylvatic ("wild") rodents. Human cases have occurred in a variety of habitats and disease foci, ranging from close to sea level on the coast, to approximately 9000 feet elevation in the Sierra Nevada Mountains. Plague bacilli have been isolated from animal sources or humans in 49 of the state's 58 counties since 1900.

Since the early epidemics, human plague cases in California have been associated with epizootics (animal disease outbreaks), most commonly among California ground squirrels, *Spermophilus beecheyi*, in foothill woodlands, inter-mountain valley grasslands, and mountainous regions throughout the length of the state (Figure 1). In addition, epizootics occur in golden-mantled ground squirrels and at least four chipmunk species in boreal forests of the state's mountain ranges, marmots and woodrats in juniper/sagebrush/lava rim habitats of Northeastern California, and woodrats and ground squirrels in chaparral/oak woodlands of Southern California.

C. Plague in Humans

1. Transmission and Incubation

Plague is principally a zoonotic disease transmitted to humans through direct or indirect contact with rodent reservoirs. The most frequent means of plague transmission to humans in California is through the bite of infected fleas (especially *Oropsylla montana*, a ground squirrel flea) from sylvatic rodents. Other potential means of transmission include contact with infected animal tissues (from rodents, rabbits, and carnivores), airborne droplets from infected humans or animals (especially cats) with plague pneumonia or pharyngitis, and laboratory *Y. pestis* cultures. Humans are accidental hosts for *Y. pestis* and do not play a role in the natural maintenance cycle of plague in California; however, humans with plague pneumonia can be a direct source of transmission for secondary cases.

The typical incubation time following exposure through direct contact or the bite of an infected flea is 2 to 6 days. For primary respiratory exposure, the incubation is usually shorter (2 to 4 days).

2. Clinical Symptoms

There are three well-described forms of plague infection in humans and several possible complications:

Bubonic Plague. This is the most common form and is characterized by an acute onset of fever and painful lymphadenopathy (“bubo”).

Septicemic Plague. This form is characterized by bacteria in the bloodstream with no apparent bubo.

Pneumonic Plague. Plague pneumonia can develop secondary to septicemic plague or can be primary following respiratory exposure to plague bacilli.

Atypical plague presentations include pharyngitis, meningitis, endophthalmitis, and cutaneous manifestations. Patients with bubonic plague who receive delayed or inadequate treatment may develop septicemia and secondary plague pneumonia. Mortality commonly exceeds 50% in untreated bubonic plague cases, while untreated septicemic and pneumonic plague cases are almost invariably fatal.

3. Diagnosis, Treatment, and Prevention

Plague is most often diagnosed through microscopic examination and culture of tissues (particularly bubo aspirate, blood, sputum, or spinal fluid) and serology. Observation of bipolar stained (Gram, Wayson) coccobacilli is suggestive but not definitive for a diagnosis of plague. Confirmation of *Y. pestis* may be made by direct florescent antibody test using the F-1 antigen, or by culture and characterization. A case is confirmed by isolation of *Y. pestis* from a clinical specimen or a four-fold rise in serum antibody titer.

Early treatment of human plague is critical to the survival of the patient. Streptomycin is the antibiotic of choice for plague, particularly the pneumonic form. Other aminoglycosides (gentamicin), tetracyclines, and chloramphenicol are acceptable alternatives in the treatment of uncomplicated bubonic or septicemic plague. While multi-drug resistant strains of *Y. pestis* have been infrequently reported from Africa, there is no evidence of reduced antibiotic susceptibility of *Y. pestis* in North America.

The California Code of Regulations, Title 17, requires strict isolation of human cases of plague. Respiratory precautions should be implemented immediately in the case of suspected or confirmed plague pneumonia. Persons with close respiratory contact to a known case should be advised to monitor themselves for onset of symptoms, particularly fever. Persons who had intimate contact with the patient or known exposure to potentially infectious tissues should be considered for chemoprophylaxis.

The Centers for Disease Control and Prevention and the World Health Organization conduct worldwide surveillance for human cases of plague. Plague, along with cholera, smallpox, and yellow fever, is an internationally quarantinable disease. Due to the potential for aerosol transmission through respiratory secretions, plague is considered a Category A (highest priority) potential biological weapon by the Working Group on Civilian Biodefense. Plague is a reportable disease under the California Code of Regulations, Title 17, Section 2500. A diagnosis of human plague must be reported immediately by telephone to the local health officer.

The human plague vaccine, previously manufactured by Greer Laboratories, Inc. (Lenoir, NC), is currently unavailable.

D. Plague in Animals

1. Sylvatic or Rural Plague

In California, plague is maintained in a cycle of infection among reservoir and susceptible rodents and vector fleas within specific geographic foci. Within each focus a cyclical disease pattern exists, alternating between periodic epizootic die-offs of susceptible rodents and inter-epizootic quiescent periods with low level disease circulation among resistant reservoirs and their fleas.

Historical and recent evidence of plague infection compiled from disease surveillance and laboratory testing of fleas, rodents (tissue and sera), and carnivores (sera) suggest that plague is present in over 40 foci in a variety of habitats within California. Most of these foci have not been adequately studied or described.

Reservoir rodent species involved in the perpetuation of plague infection in California include deer mice (*Peromyscus sp.*), meadow voles (*Microtus sp.*), and some species of woodrats (*Neotoma sp.*). Reservoir species are, in general, resistant to plague, even though they may become bacteremic. Even among

reservoir populations, however, some individual animals may at times succumb to the disease. The disease may ebb and flow among these species in a continuing enzootic cycle. Reservoir species are the fundamental components in the disease cycle and support the fleas which are capable of transferring the infection to larger, more susceptible, amplifying rodent species.

Susceptible or amplifying rodent species in California include ground squirrels (*Spermophilus sp.*), chipmunks (*Tamias sp.*), marmot (*Marmota flaviventris*), Douglas's or pine squirrel (*Tamiasciurus douglasii*), and some species of woodrat (*Neotoma sp.*). Plague epizootics among susceptible species cause animal mortality (sometimes extensive), an increase of infective fleas in the environment that can amplify the epizootic, and an elevated risk of transmission to humans through fleabites. Resistant animals within a susceptible population may survive infection and serve as a source of continuing infection for additional animals. These resistant animals may serve to perpetuate the disease over many generations in a regional plague focus.

Epizootic plague represents a much greater risk for human exposure than does enzootic plague. Reservoir rodents in an enzootic cycle do not typically die of plague. Fleas from these reservoir species tend to be rodent-specific and only rarely bite humans. In an enzootic cycle, carcasses or fleas without a host are rare. Epizootic plague, on the other hand, kills a large proportion of the susceptible rodent population. The die-off produces infective carcasses in the environment and at the same time leaves infected vector fleas without a host. Fleas from the susceptible rodents are not as host-selective as reservoir rodent fleas are, and will readily bite humans if the usual host is not available. For these reasons, epizootic plague creates a markedly increased risk for human exposure.

2. Plague in Domestic Animals

Domestic animals, especially dogs and cats, are susceptible to infection with plague, but are not part of the natural transmission cycle. However, dogs and cats may play a role in the dissemination of fleas or rodent carcasses, thereby increasing the risk of exposure to humans.

Naturally occurring plague in dogs is rarely documented and most infections are probably asymptomatic. However, like wild carnivores, infected dogs develop antibody titers in response to infection and can be valuable sentinel animals for surveillance. A high proportion of pets in a given area with elevated serologic titers may signal recent plague activity among rodents; such a finding in dogs is valuable during human case investigations when rodent populations have suffered extensive mortality and cannot be adequately sampled. Historically in California, dogs were utilized to monitor plague activity on Indian reservations and military bases.

In contrast to dogs, cats are highly susceptible to infection with *Y. pestis*. Cats most often acquire plague from feeding on infected rodents. Hunting behavior and the lack of flea control have been identified as risk factors for exposure. The disease in cats is characterized by a short incubation period of approximately two days, followed by a sudden onset of fever, lethargy, lymphadenopathy (commonly submandibular) with abscess formation (buboes), and less frequently, pneumonia. Cats with pneumonic plague show respiratory signs including sneezing, coughing, wheezing, nasal discharge (sometimes bloody), oral lesions, and/or lower respiratory signs. Untreated plague in cats is frequently fatal.

Feline plague is diagnosed by culture (bubo aspirate, blood, sputum, or carcass), direct fluorescent antibody (FA) testing, or serology. Unfortunately, diagnostic testing may be delayed, and treatment must be started immediately based on clinical impression and supportive information (e.g., bipolar, ovoid, Gram-negative organisms on microscopy from bubo aspirate or sputum).

Cats with plague represent a serious public health concern as exudates from buboes or respiratory secretions and sputum can serve as means of transmission to humans. In California, exposure to infected cats has been linked to at least four cases of human plague, three of which proved fatal. Cats with suspected plague should be treated with antibiotics by a veterinarian and placed in isolation in a veterinary hospital. Preferred treatment consists of parenteral or oral tetracycline (or tetracycline derivative). The following precautions must be taken while handling an infected cat:

a. Hospitalize the cat and place it in isolation until signs are completely resolved. Limit contact of veterinary staff to the cat.

b. Protect veterinary clinic personnel from secretions and other body fluids by using disposable surgical masks, gowns, and gloves while handling the animal. Thoroughly disinfect and dispose of all contaminated materials as medical waste.

c. Treat the cat for fleas at admission with an effective insecticide. Alert hospital staff to the potential hazard posed by fleas from the animal. Instruct the owner on how to treat the cat's environment and other household pets. Recommend professional pest control to the owner.

d. In consultation with the local health officer, owners of cats with suspected plague, the treating veterinarian and the staff, and others who had significant contact with the cat may be advised to receive prophylactic treatment. All persons who had contact with the cat should be instructed to contact their physician immediately if symptoms develop particularly fever or lymphadenopathy.

To help prevent plague in cats, pet owners should be advised to keep them confined and away from rodents. Veterinarians should provide information on safe and effective flea control to their clients. Veterinarians should instruct their staff on the safe use of insecticides for flea control in the veterinary clinic. Suspect cases of plague in dogs or cats should be reported to the Department's Vector-Borne Disease Section at 916-552-9730.

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PART II
LABORATORY DIAGNOSTICS

A. Human Plague Testing

California Department of Health Services' (CDHS) Microbial Diseases Laboratory (MDL) provides diagnostic testing for specimens from suspected human plague cases on a STAT basis. Specimens include blood (best if collected prior to antibiotic administration), lymph node or bubo aspirate, sputum, throat swab, and cerebrospinal fluid. Diagnostic testing includes Gram staining, Wayson staining, direct fluorescent antibody staining, bacteriophage testing, culture, and animal inoculation.

Submission of human plague diagnostic specimens should be coordinated through the Division of Communicable Disease Control Duty Officer at (800) 971-9631. Additional information on specimen handling protocols can be obtained by calling MDL at (510) 412-3700.

B. Animal Plague Testing

The CDHS Vector-Borne Disease Section (VBDS) laboratory staff accepts sera and diagnostic specimens and prepares them for plague microbiology or antibody testing at MDL or at the University of California - Davis, School of Veterinary Medicine (UCD).

Guidelines for sample collection and submission are distributed annually to local agencies that collaborate in plague surveillance. Specimens to be accepted include rodent or lagomorph carcasses, tissues from pet dogs and cats, fleas, sera, and blood from trapped wild carnivores or rodents absorbed onto Nobuto filter paper strips.

In order to facilitate efficient use of limited laboratory resources, the following submission criteria for animal carcasses should be adhered to:

a. Testing is limited to those small mammals most likely to be infected. This includes approximately 15 species of rodents and small carnivores in California. Contact VBDS at 510-412-6298 for advice on what animals will be tested and for submission protocols.

b. The animal should be from an area where plague is enzootic.

c. The animal should be an adult. Both young and adult animals may die from plague, but experience has shown that an adult animal is much more likely to test positive for plague than a young animal.

d. The animal should be in reasonably good condition for testing. Animals compromised by open wounds, desiccation, autolysis, or fly larvae cannot be adequately tested due to contamination from other bacteria.

e. Other causes of death, such as road kills or rodent control (poisoning), should be ruled out prior to submission of specimens.

Animal carcasses and diagnostic specimens should be sent to the VBDS laboratory (address below). Specimens should be sealed in double plastic bags and shipped on frozen "blue ice" in an insulated container via an overnight commercial carrier. Label the outside of the package with the words "Diagnostic Specimen". The VBDS laboratory must be contacted by telephone prior to specimen shipment.

Address shipment to:

California Department of Health Services
Specimen Receiving
Attn: Tina Albrecht
850 Marina Bay Parkway
Richmond, CA 94804

Attention: Vector-Borne Disease Laboratory (Telephone: 510-412-6298)

Upon receipt at CDHS, specimens are evaluated for suitability for plague testing based on carcass condition, species susceptibility to plague, and site of collection. Suitable carcasses are processed immediately, as they provide direct evidence of a plague epizootic in progress. MDL conducts FA tests and reports results to VBDS within 24 hours of receipt of suitable specimens.

CDHS also accepts and tests blood samples on Nobuto filter paper strips from rodents, lagomorphs, and domestic and wild carnivores. Fresh sera and Nobuto strips are tested for plague-specific antibodies at UCD; results are available within a week. Aspirates of lymph nodes from domestic pets are tested at MDL.

Fleas collected from live-trapped rodents and from burrows in the field are accepted for plague testing by VBDS and tested at MDL. Bacteria are isolated from fleas by mouse inoculation.

For information on the submission of diagnostic specimens from wildlife or domestic animals, contact VBDS at (510) 412-6298.

PART III
SURVEILLANCE AND CONTROL

A. Plague Surveillance

The surveillance and control of plague have been routine practices in California since the 1930s, following the human epidemics and fatalities in San Francisco and Los Angeles in the early 1900s. Public health concerns continue to be (1) the potential secondary transmission of plague through respiratory secretions from an initial human or feline case of pneumonic plague, (2) the potential transfer of the infection from the sylvatic source to commensal rat populations in heavily urbanized regions, (3) the export of an incubating human case from California's plague-endemic recreational areas to a location where the disease may not be recognized, thus potentiating person-to-person transmission, and (4) the continuing potential for human exposures in persons living in or traveling to plague endemic areas in California. Consequently, the surveillance, prevention, and control of plague remain important public health activities in California.

The California Plague Surveillance and Control Program is a cooperative inter-agency program involving state, federal and local agencies under the direction of CDHS. The program is instrumental in the prevention of human cases by utilizing education, epidemiological investigation, surveillance of host and vector populations, serological testing of domestic and wild carnivores, diagnostic testing, vector suppression, and disease outbreak management.

Thirty-nine (39) human cases and seven fatalities have been reported in California since 1970, a significant increase in cases over previous decades (1930-1970 averaged 4 cases per decade). At least eight of the 39 cases (20%) developed secondary plague pneumonia. All these cases were associated with either direct or indirect contact with the sylvatic rodent plague cycle. Fatality among cases in California, as in other western states, has remained at 20 to 25%, despite the availability of effective antibiotic therapy.

The goal in plague surveillance is to protect the public through early detection and suppression of plague transmission in the sylvatic cycle. This goal is consistent with the letter and intent of international and state health regulations. Plague is well established in California's sylvatic rodent populations within a framework of geographical disease foci. The hazard to the public is generally low, but increases significantly when epizootics occur among susceptible rodent populations. In California, the greatest risk for human plague in the sylvatic or rural cycle is attributed to the presence of one or two ground squirrel species (*Spermophilus beecheyi and S. lateralis)* and their shared flea vector (*Oropsylla montana*). In the state's mountainous regions, there is an additional risk associated with various chipmunk species *(Tamias sp*.) and their shared flea vectors (*Eumolpianus eumolpi, Ceratophyllus sp*.)

B. Plague as a Biological Weapon

A modern risk from plague involves the threat of an intentional aerosol release of the plague bacteria into an urban area. Although commensal rats and their fleas in California have not been involved with human plague cases since the 1920s, a bioterrorism release of *Y. pestis* into an urban area could infect humans and commensal rodents alike. An airborne release of plague bacteria may result in initial human pneumonic plague cases, and also may precipitate plague epizootics among rats and a secondary wave of human cases transmitted by rat fleas.

Medical and public health response and management of plague in the event of its use as a biological weapon are summarized in a Consensus Statement of the Working Group on Civilian Biodefense (JAMA 2000; 283:2281-90). There is a need for health authorities to develop response plans that specify what vector and rodent control measures need to be taken following the release of plague bacteria during a bioterrorism event.

C. Sylvatic Plague Epizootic Response

Plague in wild rodents in California is characterized by periodic, often explosive, epizootic die-offs among susceptible rodents within geographical disease foci. Plague exists as a permanent, latent infection among resistant reservoir species (deer mice, meadow voles) within a given focus. Rodent fleas serve as transmitters or vectors of infection among rodent populations. The disease becomes epizootic when the infection enters into susceptible rodent populations (ground squirrels, chipmunks) which are receptive in terms of population density, vector flea abundance, and other factors that encourage epizootic amplification.

The geographic scope and ecologic complexity of sylvatic rodent plague in California creates a diverse set of surveillance and control problems. Plague control can best be accomplished through an integrated approach involving surveillance, education, habitat management to reduce rodent attraction, control of vectors, and occasionally, rodent population management. Due to the periodic expression of epizootic plague in animal populations, appropriate monitoring and surveillance by trained vector-borne disease specialists is indispensable in plague endemic regions with a history of epizootics and human cases.

Knowledge or suspicion of plague epizootics should always be reported to local health authorities, and the attendant risk of disease transmission assessed by trained vector control biologists and technicians. Knowledge of surveillance and control/management techniques by trained specialists is indispensable in preventing human cases.

Plague activity may peak during some years in which epizootics occur over hundreds of square miles under conditions of high host and vector densities. Rodents may die in areas only sparsely inhabited or rarely visited by humans. Mass control activities in these areas, even if logistically and economically feasible, are not justified by the limited risk of exposure and infection to humans. For this reason, control strategies are aimed primarily at prevention of human contact with sylvatic rodents and their fleas by specific actions to reduce rodent and flea populations in areas of human residence and activity. The presence of plague in a dense population of susceptible rodents closely associated with human activity sometimes necessitates the use of insecticides to reduce the number of potentially infective vector fleas and lessen the transmission risk to humans. In many instances, temporary closure of recreational facilities for plague control is required.

1. Epizootic Investigation and Risk Evaluation

Reports of animal die-offs should be investigated in a preliminary fashion by local health authorities to determine if a plague epizootic is in progress and if the public is at risk of disease. Included in the survey should be a determination of the rodent species involved, an estimate of their population densities, and an assessment of the potential for contact between humans and rodents in the die-off area. An effort should be made to obtain fresh rodent carcasses and/or fleas from burrow systems for laboratory testing. Evidence of poisoning or shooting should be ruled out as the cause of rodent deaths. Rodents should not be handled directly; rodent carcasses can be safely retrieved by reaching through a plastic bag to grasp the animal, inverting the bag over the animal without directly touching it, and sealing the bag. Label the outside with collection information.

Isolation of *Y. pestis* from a rodent carcass submitted from an epizootic die-off indicates active transmission of plague in the rodent population. This information should trigger a more intensive survey and risk evaluation, and possible control recommendations to protect the public health "Plague Warning" signs should immediately be posted in areas with confirmed epizootic plague. The general public should be notified through a media release.

A more comprehensive environmental investigative survey should include:

a. Live-trapping rodents to estimate the population densities of known plague amplifying species and collection of serum specimens for assessment of plague transmission activity.

b. Assessing the extent and phase of the epizootic.

c. Evaluating the abundance of known vector fleas (flea index).

d. Assessing the exposure potential to humans from these vector fleas.

e. Reviewing the past history of epizootics and/or human plague cases in the region.

Confirmation of plague among susceptible rodent species and/or their fleas, high densities of such hosts and important vector fleas, a past history of epizootics and/or human cases, and the imminent exposure possibility to humans in an area of high human activity may require intervention in the disease cycle through control of vector fleas and rodent populations. Plague control is a collaborative effort between state and local health and agricultural authorities and, in recreational situations, federal, state, and local land use agencies, and private interests. Decision flowsheets used in epizootic plague response are included as Figures 2-4.

2. Control of Rodent Fleas

The bite of infective fleas remains the most frequent route of plague transmission to humans in California. Therefore, insecticidal control of sylvatic rodent fleas is the most effective means of interrupting human contact with the plague vector. Control of fleas on dogs and cats is indicated in enzootic regions during plague epizootics because pets may serve as transporters of rodent fleas to humans. Numerous insecticides and insect growth regulators are commercially available for control of fleas on dogs and cats. These products can be administered by the pet owner or veterinarian.

The decision to control vector fleas on sylvatic rodents is based on:

a. The presence of susceptible rodents and vector fleas in areas of human activity.

b. A high potential for humans to be exposed to vector fleas.

c. Confirmation of epizootic plague among susceptible rodents and/or fleas in areas of human activity.

d. A history of epizootics and/or human cases in the area in question.

Control measures are limited to areas of actual or potential human exposure at the time of treatment. Under this regimen, routine and repetitive treatments which might lead to development of insecticide resistance are avoided. Reduction of flea density to less than one flea per rodent host is considered sufficient to interrupt transmission to humans.

The means by which insecticides are delivered to the target species are as important as the materials used. Two target delivery systems are currently approved and employed:

(1) Application of insecticidal dusts into rodent burrow systems.
(2) Application of insecticides via rodent bait stations. This method targets fleas on animals that do not use burrows for nesting.

Both methods of insecticide application may be necessary where mixed rodent populations (e.g., ground squirrels and chipmunks) are involved in the disease cycle.

Burrow dusting for flea control is accomplished by insufflating insecticide dust directly into rodent burrow systems with hand or pressurized dusters. Burrow dusting is most effective against ground squirrel fleas where rodent burrows are easily located.

Bait stations attract rodents by using a bait block or other material suspended above a layer of insecticide dust. Animals dust themselves while feeding on the bait block and on entering and leaving the station. Alternatively, a liquid insecticide can be applied to carpet lining the inside of a modified bait station. Bait stations should be inspected every other day and attractant and insecticide refilled as necessary. Bait stations are most effective against fleas on ground squirrels, chipmunks, pine squirrels, and woodrats. Occasionally, dominant species and individuals within a species may deter entry of other animals into bait stations, thus leaving the more subordinate species or individuals untreated. A sufficient number of bait stations should be deployed to accommodate the rodent population density and dynamics. Bait stations should be placed no greater than 30 meters apart. Current pesticides available for rodent flea control require approximately seven days of use in bait stations to be effective.

New and improved methods for rodent flea control are currently under investigation. Possible methods include the use of new insecticides and insect growth regulators for the control of plague vector fleas. The rapid reduction of infectious fleas remains the prime objective in epizootic plague control.

3. Pesticide Application and Safety in Flea Control

Insecticidal exposure to both applicators and the general public is of critical concern in plague control. All label directions, worker safety regulations, and common sense practices must be followed to reduce the chances of human and non-target wildlife exposure. All pesticide applicators must be properly certified or work under the direct supervision of a certified applicator. Prior to handling pesticides, all applicators are required to receive pesticide safety training for the specific pesticide product(s). A written record of safety training must be maintained for all applicators.

Applicators must wear the personal protective equipment specified on the pesticide label or required by regulation; this may include disposable protective coveralls, rubber gloves, head and foot protection, and protective eyewear. An approved respirator must be worn for those operations that require transfer of pesticide from a large container to a service container and other activities where there is respiratory exposure. Persons who apply pesticides should be trained in the proper use of respiratory equipment; also, some respirators (e.g., half-mask negative pressure) must be properly fit to the individual prior to use. Washing facilities must be available for all control operations.

Exposure of the public to insecticides should be minimized during all plague control operations by restricting access to the control site. The public should be notified in advance of any application procedures. Bait stations in campgrounds present a potential source of poisoning for children and pets. Bait stations should be constructed, placed, and labeled in such a manner as to prevent possible pesticide poisonings.

A post-treatment evaluation should follow all rodent flea control operations to determine success or failure of flea reduction and environmental impacts to non-target wildlife species. Appropriate reports on pre- and post-treatment evaluations and a summary of the control operation should be filed accordingly. Pesticide use reports indicating county where applied, agency involved in application, formulator and product used, EPA and California registration numbers, the targeted pests, concentration, and the amount of pesticide used, should be submitted to the county agricultural commissioner and other appropriate agencies for each plague control operation.

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PART IV
PLAGUE PREVENTIVE MEASURES

Regions with a history of plague epizootics among sylvatic rodents should not rely solely on chemical control of flea populations as a comprehensive prevention strategy. An integrated disease management program that includes host population and disease monitoring, public education, and habitat manipulation to restrict rodent abundance must be adopted. Present biological and management knowledge, if properly used, can minimize potential disease hazards to humans, as well as reduce the need for intervention and temporary closure of public use areas.

A. Rodent Management

Rodent populations, properly limited in size, can contribute to the aesthetic quality of recreational activities for many people. However, the temptation to feed rodents, particularly in recreational situations, is both biologically and ecologically undesirable. Human-influenced habitat changes and increased food supply through supplemental feeding contribute heavily to increased rodent populations.

In plague control, the following two questions are of importance: "What is an increased rodent population?" and "How many is too many"? Wildlife managers and vertebrate pest specialists suggest that if ground squirrels have established burrows under or around 20% or more of structures, barriers, or campsites in a campground, then their numbers exceed desirable levels. If 2-3 ground squirrels can be seen at any one time per acre (5-7 per hectare) in areas other than campgrounds, then their numbers are excessive.

Periodic plague epizootics and high densities of plague-susceptible rodents in close proximity to humans may lead to a management strategy that incorporates control or reduction of excessive numbers of rodents. Reduction of rodents may also reduce or prevent rodent-caused facility damage.

Various management and control methods can be used to reduce the numbers of rodents or the frequency of human-rodent contacts. These include sanitation, habitat modification, rodent proofing, trapping, toxic baits, and fumigants. Removal of rodents may be conducted in concert with flea suppression activities. However, it is essential to ensure that fleas are controlled prior to rodent control to avoid potential human exposure to infected fleas.

1. Sanitation

Rodents normally obtain food from natural sources. However, they are opportunistic and will readily take advantage of supplemental food such as garbage, spilled pet food, or handouts from campers and recreational area visitors. Dumpsters and garbage cans should be tightly sealed; spillage and accumulation of trash and food outside of containers should be discouraged or eliminated. Every attempt should be made to discourage people from feeding wild rodents.

2. Habitat Modifications

Human-influenced habitat features (e.g., barrier logs, rock walls, concrete pads) are a major contributing factor to rodent population enhancement, particularly when coupled with added food supplies. Human-influenced habitat features additionally contribute to human-rodent-flea contact and plague risk exposure.

Burrowing rodents, such as ground squirrels, benefit from the addition of structures, large boulders, fallen logs, or piles of lumber or other materials to the environment, particularly when burrowing is possible in loose soil directly under the structure or material. Additional benefits are derived by rodents if the structures or materials lend themselves to construction of nest sites. Thick brush cover may greatly influence rodent species in their movements, home range, and nest site selection.

Basic recommendations for habitat modification of both recreational and home environments include the following:

a. Thick brush should be trimmed back at least 15 feet (5 meters) from homes and structures, or from campsites in recreational areas.

b. Fallen logs should be removed.

c. Logs used as barriers should be placed on pedestals at least six inches off the ground.

d. Tree stumps should be cut down below grade and eliminated.

e. Large rocks used as barriers or for decorative purposes should be partially buried, 1/3 to 1/2 below grade. In campgrounds, campsites should be located away from large rocks or boulders where rodents normally construct burrow systems.

f. After road construction, rocks should be removed and banks well compacted. Metal barriers, rather than logs, should be used as roadway barriers.

g. Exposed root systems from trees should be covered and compacted.

h. L-shaped concrete lips or stiff wire mesh (10 inches wide and buried 8 inches below ground adjacent to pads) should be used instead of shallow concrete pads or low wooden risers in construction.

i. Gaps between walls and roofs, and access areas of lower walls in structures should be sealed.

j. Supplemental food and free water (leaking faucets, etc.) should be reduced.

3. Rodent Proofing

Restricting rodents from buildings depends on various exclusion methods such as screening of vents, making doors tight fitting, and plugging spaces where pipes enter buildings. Proper design of buildings and facilities can play a large role in preventing rodent access.

4. Trapping

Although labor-intensive, trapping may be an effective auxiliary method of reducing rodent numbers. Enough traps must be used and live-traps should be checked frequently so that any non-target animals can be released quickly. Because rodents such as ground squirrels and chipmunks are disease hosts, and animals relocated from their home range have limited survival potential, live-trapped animals should not be released elsewhere. Relocation of rodents and other wildlife is also illegal. Animals live-trapped for removal should be humanely euthanized. In regions with a history of epizootic plague, rodent control must be preceded by flea control, as outlined above.

Live or snap traps can be used for trapping ground squirrels, chipmunks, or woodrats. Rubber or plastic gloves should be worn when handling rodent carcasses. Dead rodents should be double bagged in tightly sealed plastic bags and properly disposed or buried.

Special precautionary methods are recommended when trapping rodents (Methods for trapping and sampling small mammals for virologic testing, Sept. 1995, U.S. Dept. Health & Human Services, CDC; American Society of Mammalogists, Journal of Mammalogy 79(4), 1998). Workers must identify whether any species listed as endangered or threatened occur in the region where trapping is intended. Workers should be aware of the symptoms of rodent-borne diseases and should immediately seek medical attention if a febrile illness develops after a potential exposure. People involved in live-trapping or otherwise handling live rodents should wear protective gear including disposable coveralls, rubber boots or disposable shoe covers, rubber or plastic gloves, protective goggles, and an appropriate respiratory protection device such as a half-mask air-purifying (or negative-pressure) respirator with a high-efficiency particulate air filter (N-100 HEPA) or a powered air-purifying respirator with HEPA filters. Respirator safety training should be provided to individuals prior to any respirator usage. A respirator fit test must be conducted if half-face negative pressure respirators will be used.

5. Toxic Baits

Chronic or multiple-dose anticoagulant rodenticides are considered the safest baits to use with minimal risk for human and non-target species. Baits must be consumed over a number of days to be lethal because anticoagulant toxicity is cumulative. Anticoagulant baits are readily accepted by wild rodents, and rodents rarely develop bait shyness. The best time to use anticoagulants is in the spring after rodents have emerged from hibernation. In regions with a history of epizootic plague, rodent control must be preceded by flea control, as outlined above.

Application of toxic baits for rodent control should be coordinated with the County Agricultural Commissioner prior to use. A permit is required from the Commissioner and pesticide use reports must be submitted on a monthly basis. When anticoagulant baits are used in bait stations, the stations must be designed and placed so as to not allow access to the pesticide by people and other non-target animals. Label instructions must be followed carefully during the application of anticoagulant baits.

An awareness of any endangered or threatened species in a region should always be considered in rodent management operations where toxic baits may be used as a control method.

6. Fumigants

Some fumigants are very effective for controlling burrowing rodents such as ground squirrels. The use of fumigants is limited to times of the year when animals are not hibernating or estivating. The best time to use most fumigants is in the spring after rodents have emerged from hibernation. Fumigants are most effective when the soil is moist, because moisture prevents the gas from escaping the burrow system. Do not use fumigants under buildings where fumes could escape into buildings from burrow systems. In regions with a history of epizootic plague, rodent control must be preceded by flea control, as outlined above. Some fumigants have the added benefit of simultaneously controlling both rodents and fleas.

Due to their toxicity, fumigants are restricted-use pesticides. The operator is required to obtain a restricted materials permit from the County Agricultural Commissioner prior to the use of these pesticides. Restricted materials permits may be issued only to licensed or certified personnel. Label restrictions must be closely adhered to and the Commissioner may impose permit conditions on the use of fumigants that are more stringent than the label requirements.

B. Health Education

The appropriate and timely use of news media, informational brochures, posters, and word-of-mouth information in the form of lectures, interpretive programs, and training courses are key elements of plague control. Many sylvatic rodent associated plague cases can be prevented. Individuals who reside in enzootic regions can be educated to avoid potentially plague-infected rodents and fleas. Residents can be trained to treat pets for fleas, remove rodent harborage, rodent-proof structures, and carry out control measures against rodents and fleas on their properties.

Campers and visitors to recreation areas can be alerted with plague leaflets and posters that explain the hazards of plague, how to avoid it, and where to report evidence of rodent morbidity or mortality. Areas where exposure risk is deemed high during epizootics, or areas undergoing flea control, may be temporarily closed until the risk to humans is minimized.

In addition to public information, the medical and veterinary communities should be kept informed of plague surveillance and provided with current information on case occurrence, diagnosis, and therapy.

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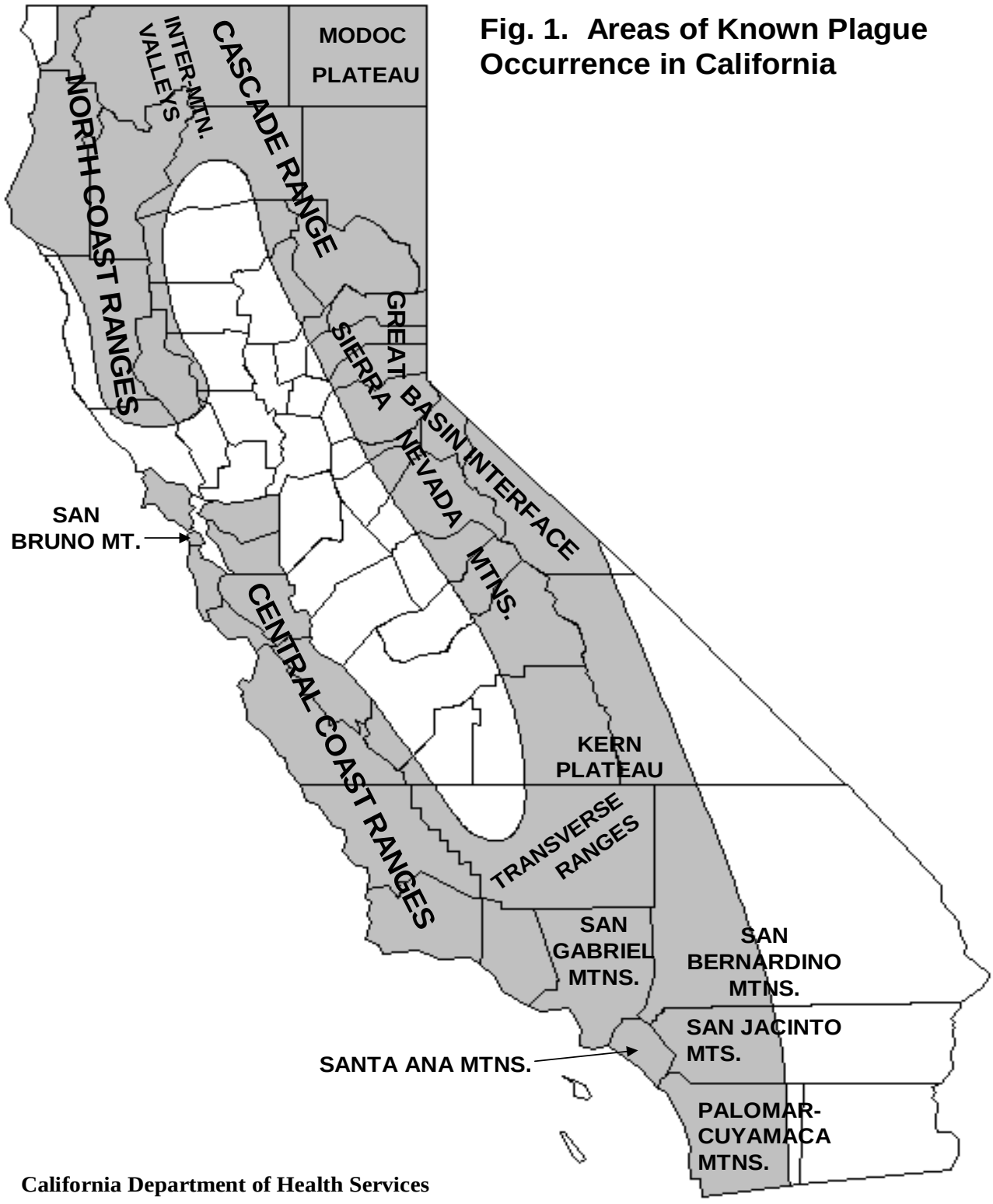
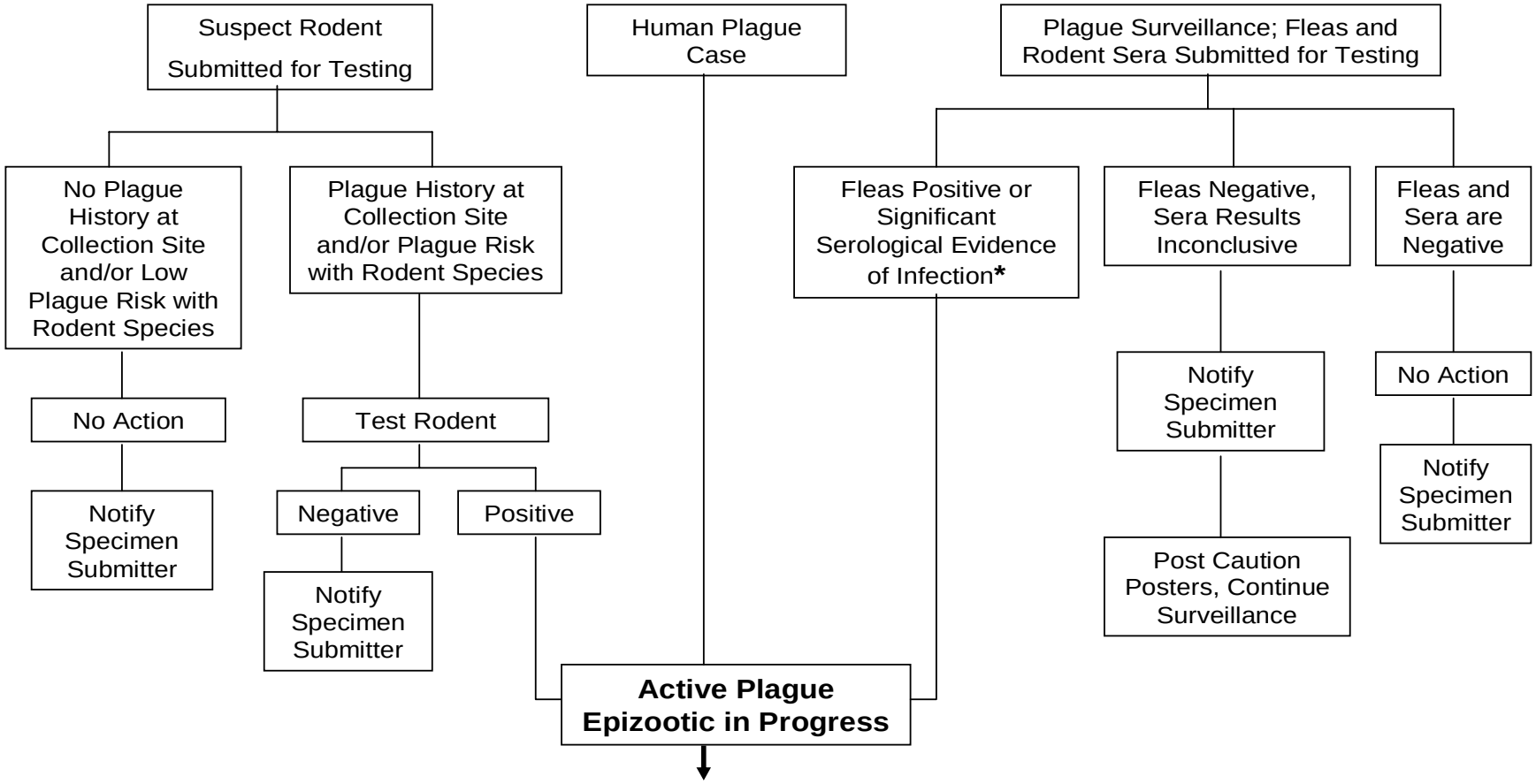
Fig. 1. Areas of Known Plague Occurrence in California



California Department of Health Services
Vector-Borne Disease Section

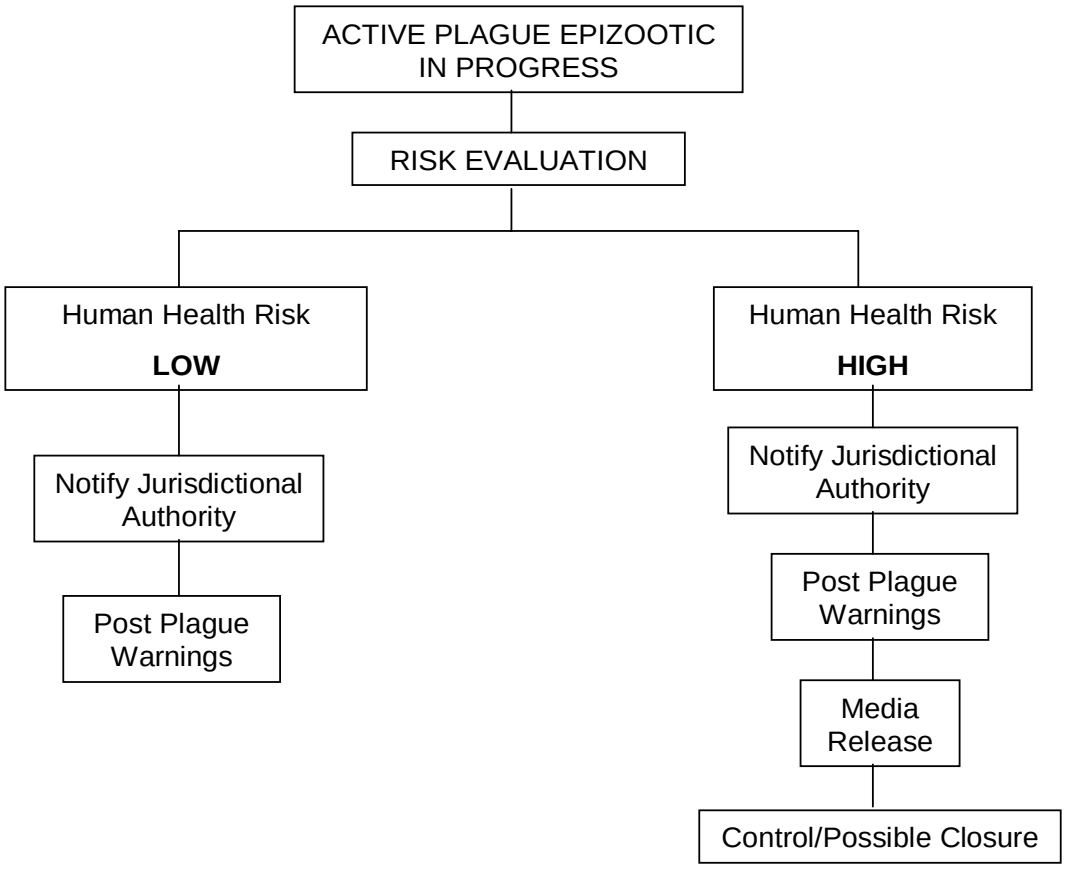
Fig. 2. Plague Detection



(Leads to Fig. 3. Plague Epizootic Evaluation)

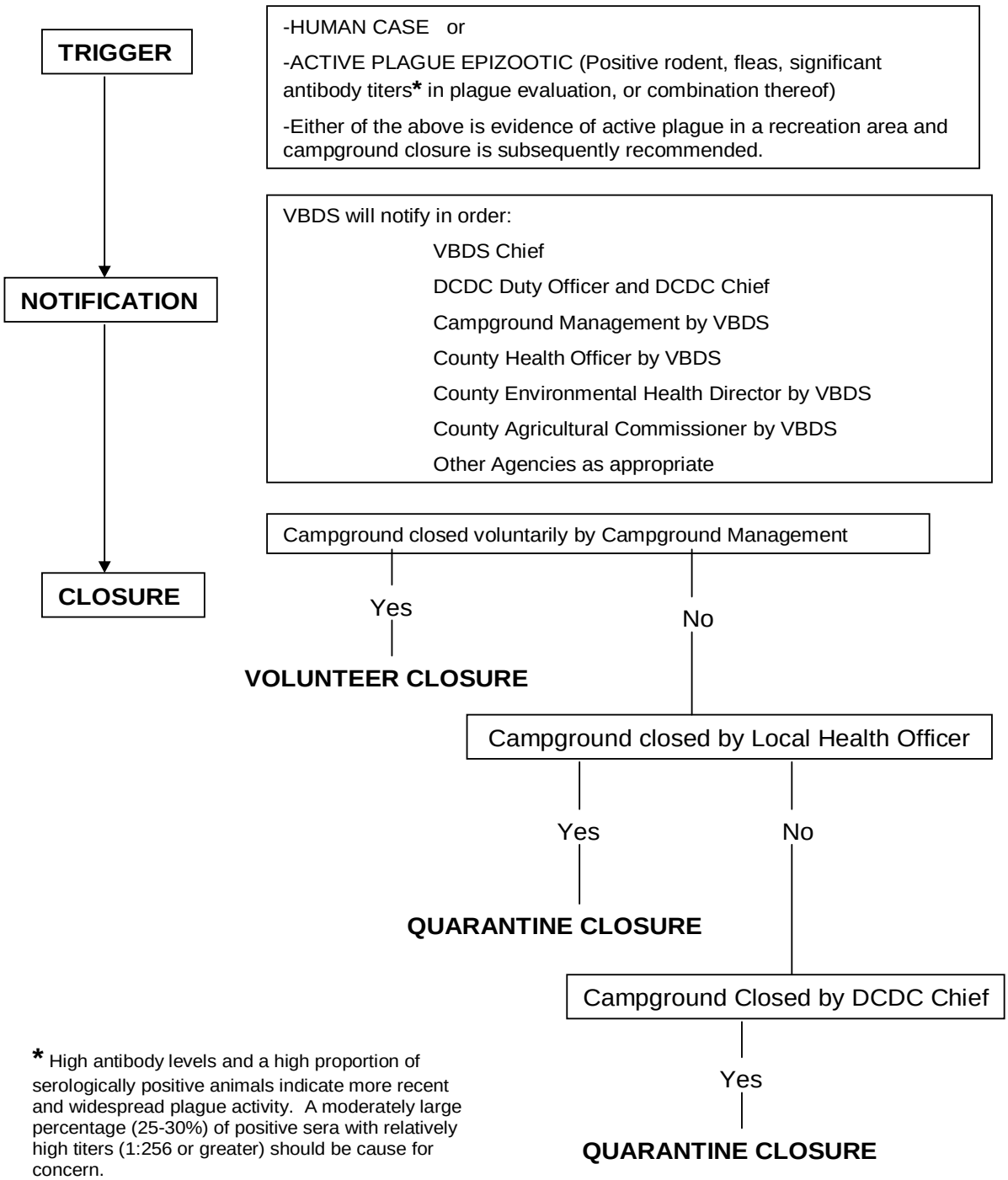
* Refer to footnote on Figure 4.

Fig. 3. Plague Epizootic Evaluation



RISK EVALUATION:	**CONTROL/CLOSURE RECOMMENDED IF:**
1. Past history of disease and evidence of current epizootic activity.	History of past disease and current epizootic documented.
2. Presence of susceptible versus resistant rodent species and densities.	High density of disease susceptible host rodent species present.
3. Presence of vector fleas and bite exposure potential.	Vector fleas present, species readily bite humans – exposure potential for human transmission is high.
4. Human usage and exposure potential.	High human usage and close co-mingling of humans, disease hosts, and vectors.
5. Human exposure risk from pesticide application.	Potential for pesticide exposure to humans.

Fig. 4. Procedures for Campground Closure Plague Prevention



* High antibody levels and a high proportion of serologically positive animals indicate more recent and widespread plague activity. A moderately large percentage (25-30%) of positive sera with relatively high titers (1:256 or greater) should be cause for concern.